

# Chapter 1

## Exploring Life

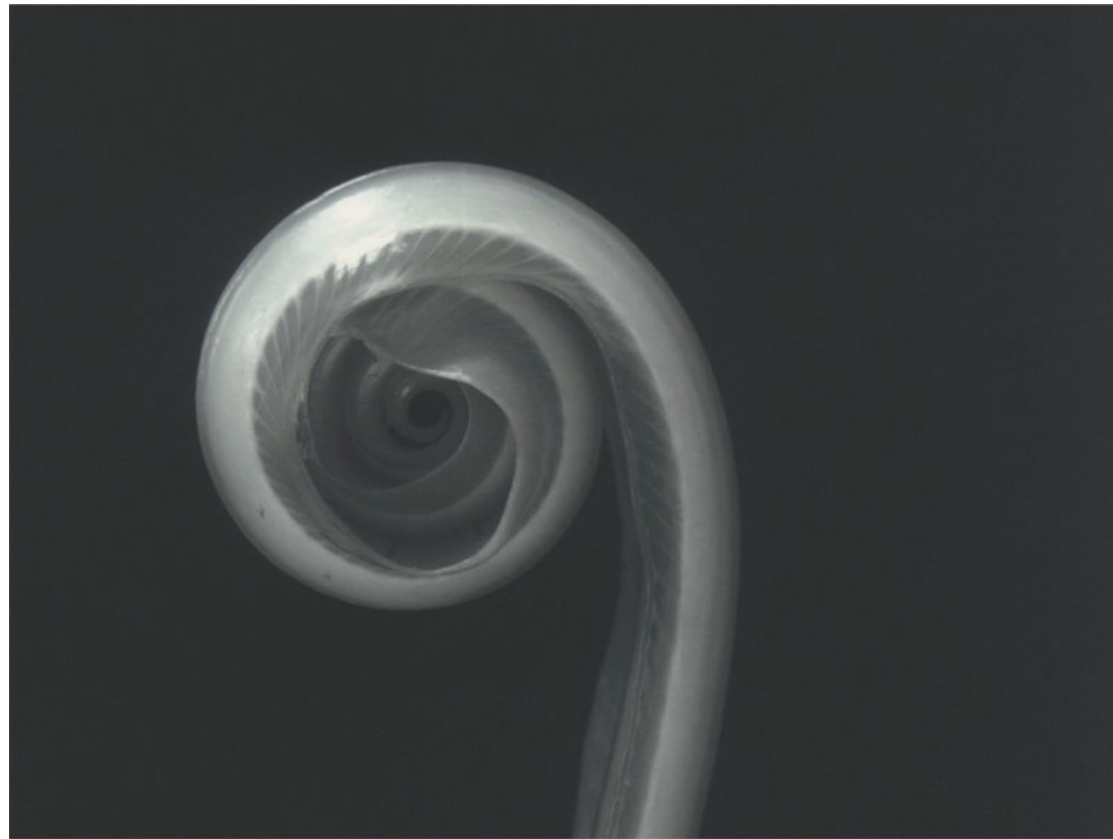
PowerPoint Lectures for  
***Biology, Seventh Edition***  
*Neil Campbell and Jane Reece*

**Lectures by Chris Romero**

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- Overview: Biology's Most Exciting Era
  - Biology
    - Is the scientific study of life

- 
- The phenomenon we call life
    - Defies a simple, one-sentence definition



**Figure 1.1**

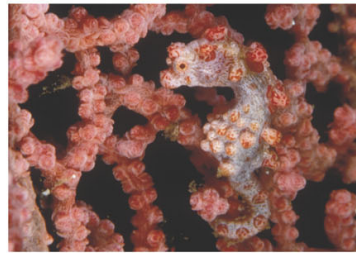
- 
- We recognize life
    - By what living things do

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- Some properties of life



**(a) Order**



**(b) Evolutionary adaptation**



**(c) Response to the environment**



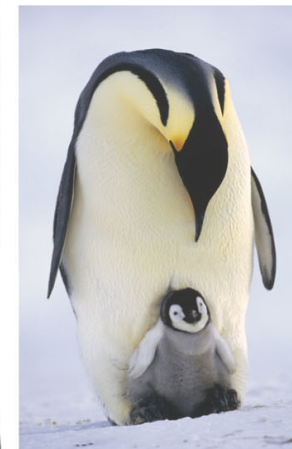
**(d) Regulation**



**(e) Energy processing**



**(f) Growth and development**



**(g) Reproduction**

**Figure 1.2**

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- Concept 1.1: Biologists explore life from the microscopic to the global scale
  - The study of life
    - Extends from the microscope scale of molecules and cells to the global scale of the entire living planet

# A Hierarchy of Biological Organization

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- The hierarchy of life
  - Extends through many levels of biological organization

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- From the biosphere to organisms

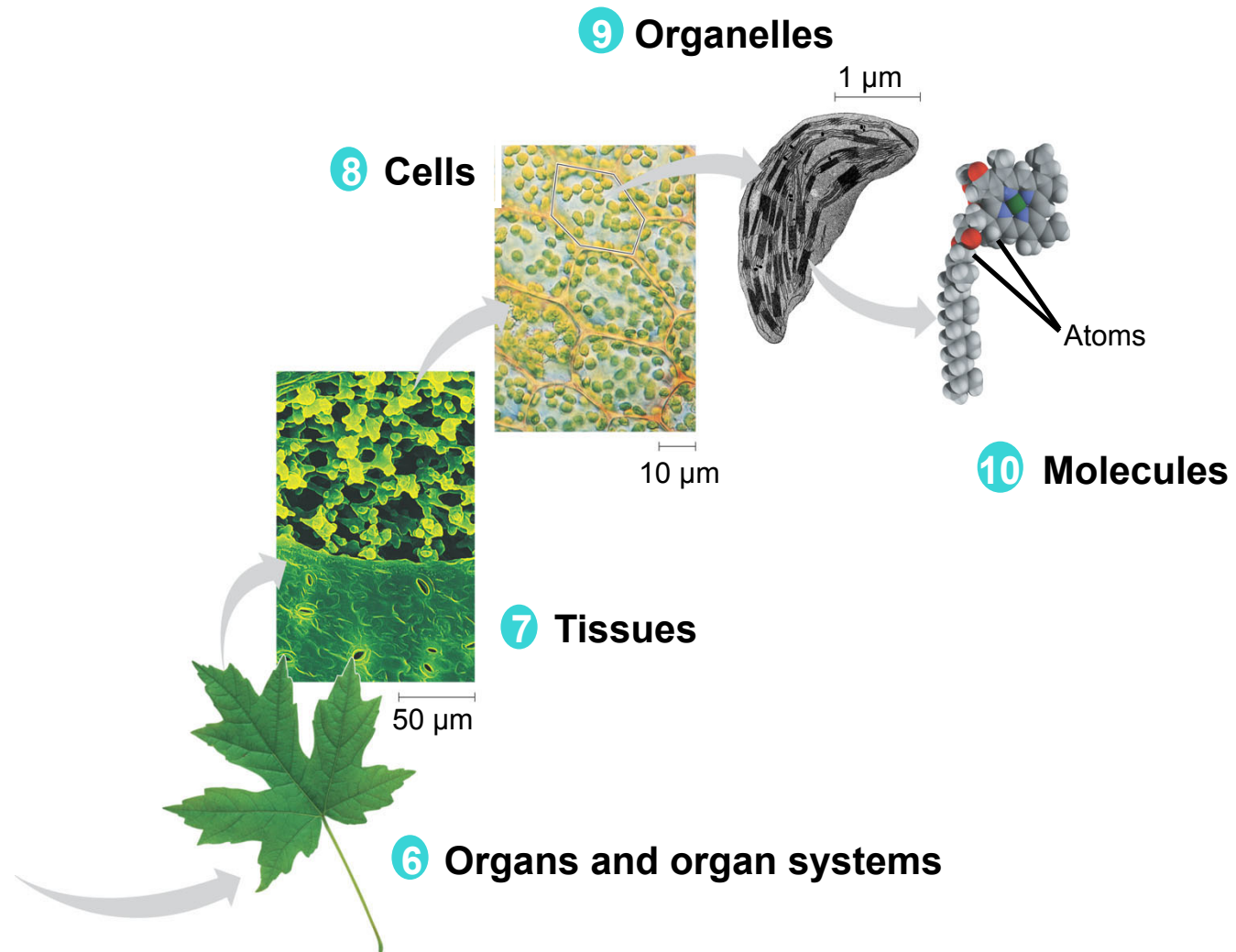
- 1 The biosphere



**Figure 1.3**



- From cells to molecules



**Figure 1.3**

# A Closer Look at Ecosystems

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- Each organism
  - Interacts with its environment
- Both organism and environment
  - Are affected by the interactions between them

## *Ecosystem Dynamics*

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- The dynamics of any ecosystem include two major processes
  - Cycling of nutrients, in which materials acquired by plants eventually return to the soil
  - The flow of energy from sunlight to producers to consumers

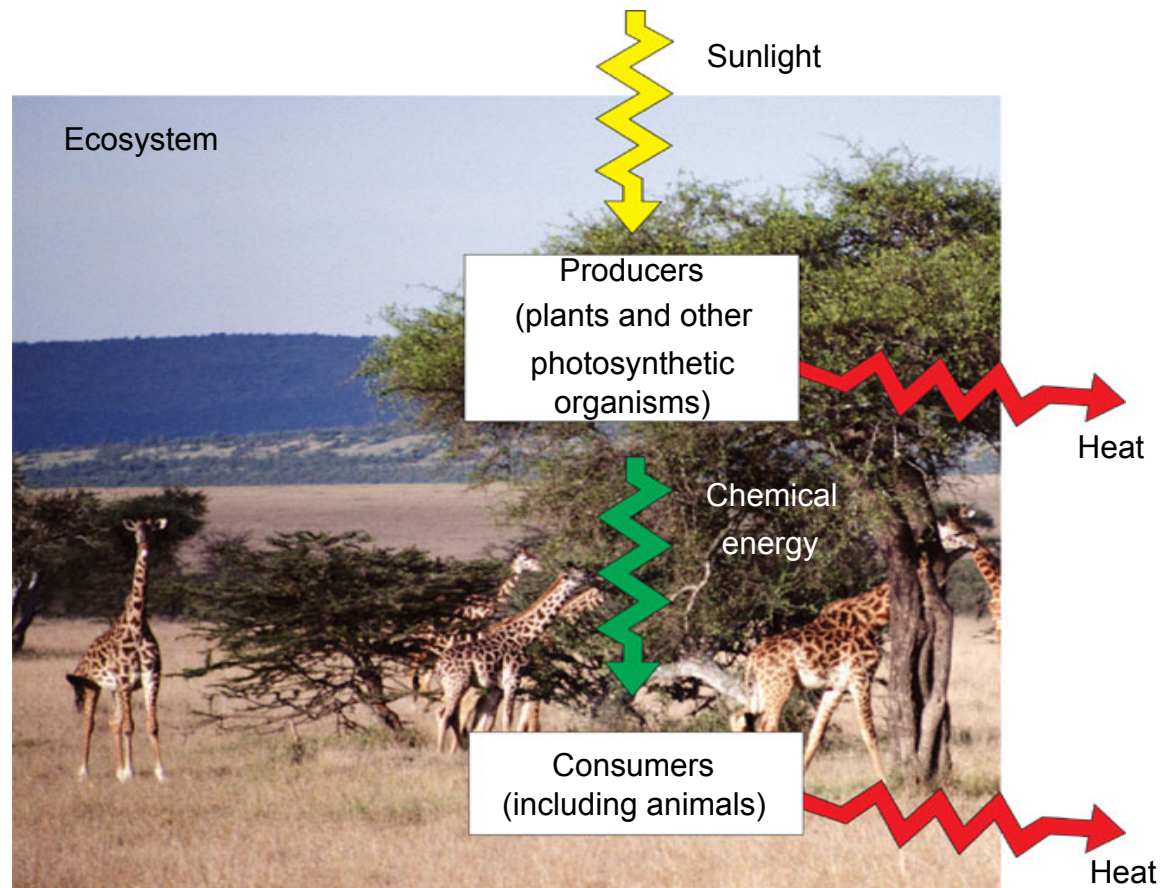
# *Energy Conversion*

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- Activities of life
  - Require organisms to perform work, which depends on an energy source

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- The exchange of energy between an organism and its surroundings
    - Often involves the transformation of one form of energy to another

- Energy flows *through* an ecosystem
  - Usually entering as sunlight and exiting as heat

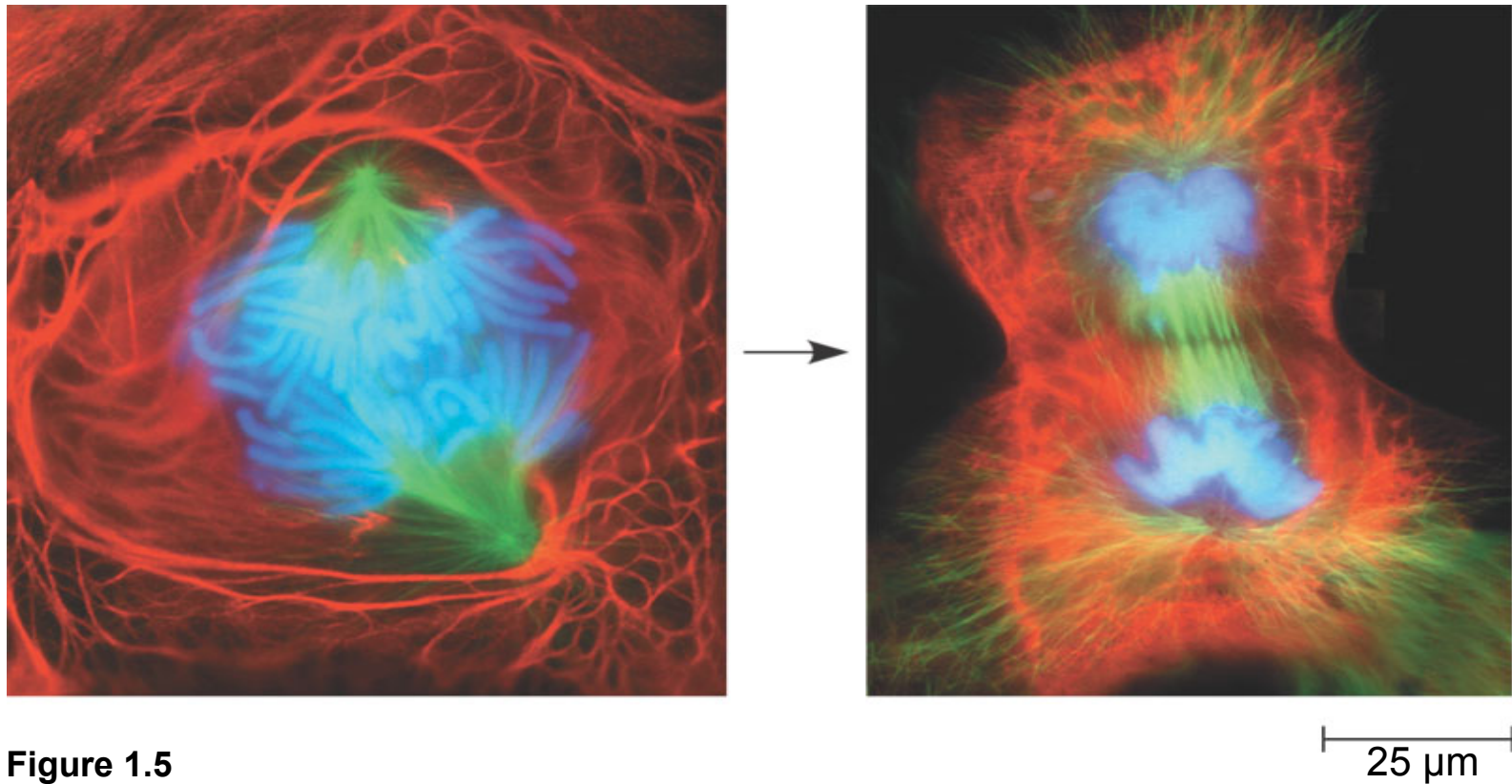


**Figure 1.4**

# A Closer Look at Cells

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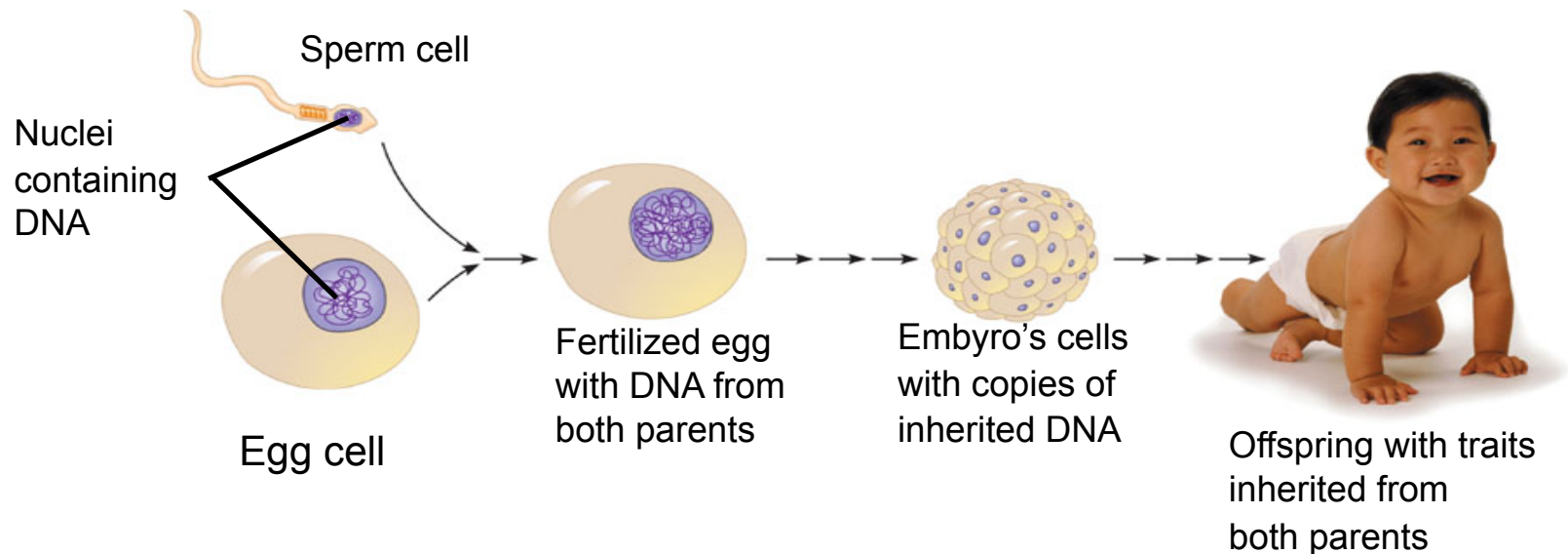
- The cell
  - Is the lowest level of organization that can perform *all* activities required for life



# *The Cell's Heritable Information*

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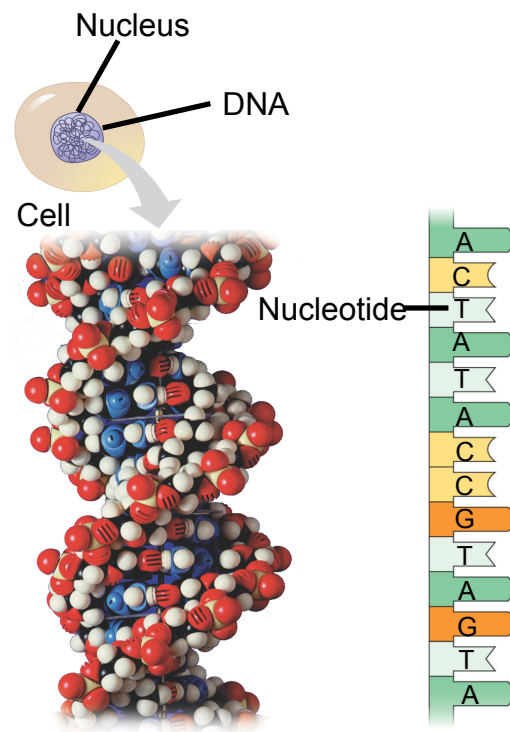
- Cells contain chromosomes made partly of DNA, the substance of genes
  - Which program the cells' production of proteins and transmit information from parents to offspring



**Figure 1.6**



- The molecular structure of DNA
  - Accounts for its information-rich nature



**(a) DNA double helix.** This model shows each atom in a segment of DNA. Made up of two long chains of building blocks called nucleotides, a DNA molecule takes the three-dimensional form of a double helix.

**(b) Single strand of DNA.** These geometric shapes and letters are simple symbols for the nucleotides in a small section of one chain of a DNA molecule. Genetic information is encoded in specific sequences of the four types of nucleotides (their names are abbreviated here as A, T, C, and G).

**Figure 1.7**

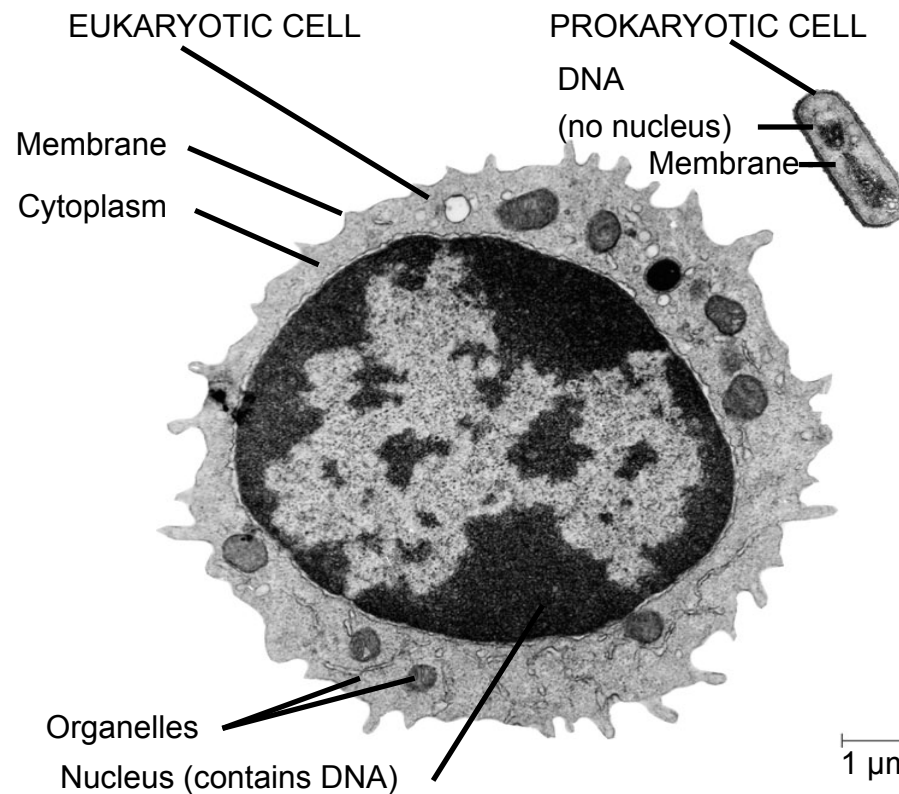
## *Two Main Forms of Cells*

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- All cells share certain characteristics
  - They are all enclosed by a membrane
  - They all use DNA as genetic information
- There are two main forms of cells
  - Eukaryotic
  - Prokaryotic

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- Eukaryotic cells
    - Are subdivided by internal membranes into various membrane-enclosed organelles

- Prokaryotic cells
  - Lack the kinds of membrane-enclosed organelles found in eukaryotic cells



**Figure 1.8**

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- Concept 1.2: Biological systems are much more than the sum of their parts
  - A system
    - Is a combination of components that form a more complex organization

# The Emergent Properties of Systems

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- Due to increasing complexity
  - New properties emerge with each step upward in the hierarchy of biological order

# The Power and Limitations of Reductionism

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- Reductionism
  - Involves reducing complex systems to simpler components that are more manageable to study

- The study of DNA structure, an example of reductionism
  - Has led to further study of heredity, such as the Human Genome Project



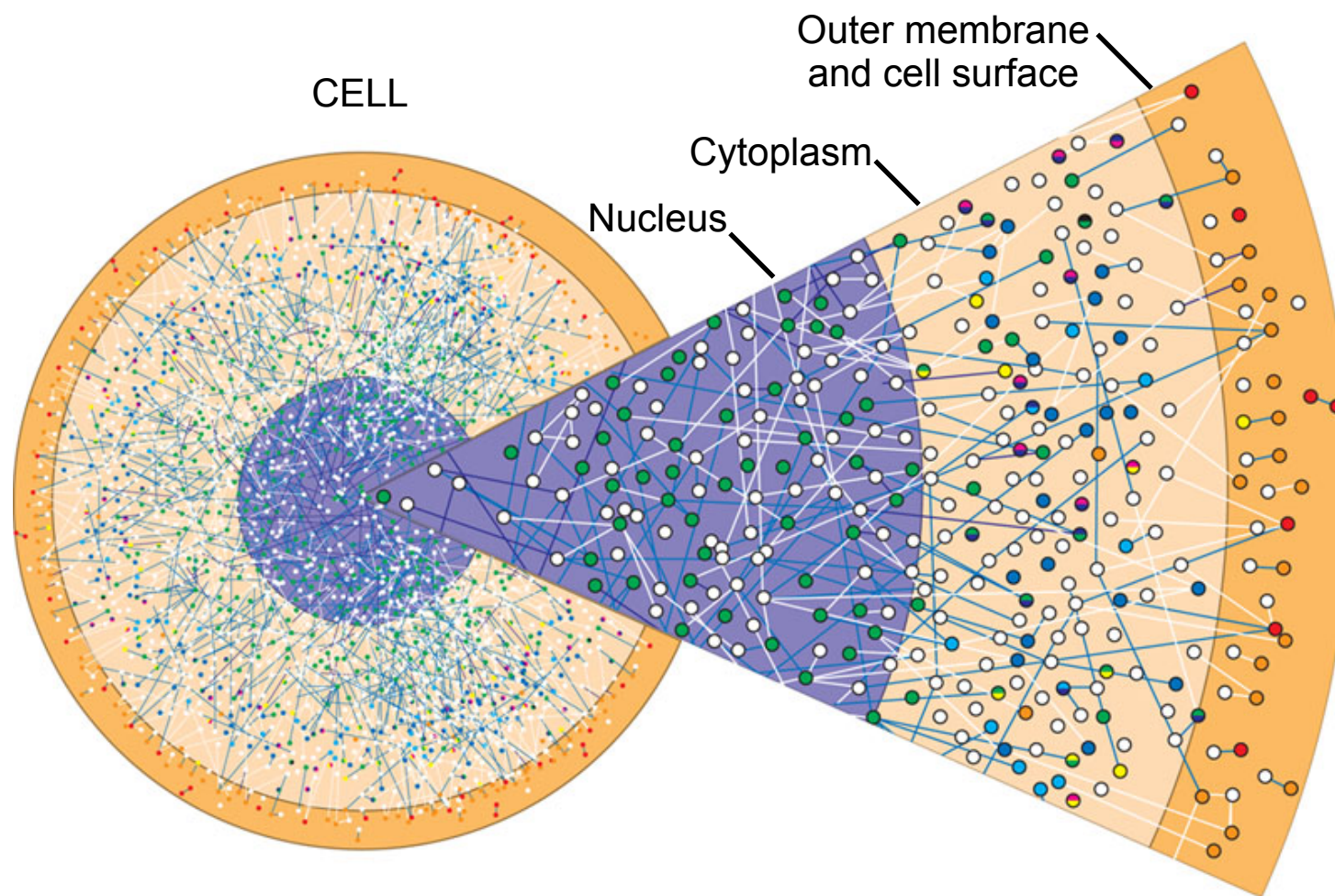
**Figure 1.9**



# Systems Biology

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- Systems biology
  - Seeks to create models of the dynamic behavior of whole biological systems
- With such models
  - Scientists will be able to predict how a change in one part of a system will affect the rest of the system



**Figure 1.10**

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- Systems biology
    - Is now taking hold in the study of life at the cellular and molecular levels
    - Includes three key research developments: high-throughput technology, bioinformatics, and interdisciplinary research teams

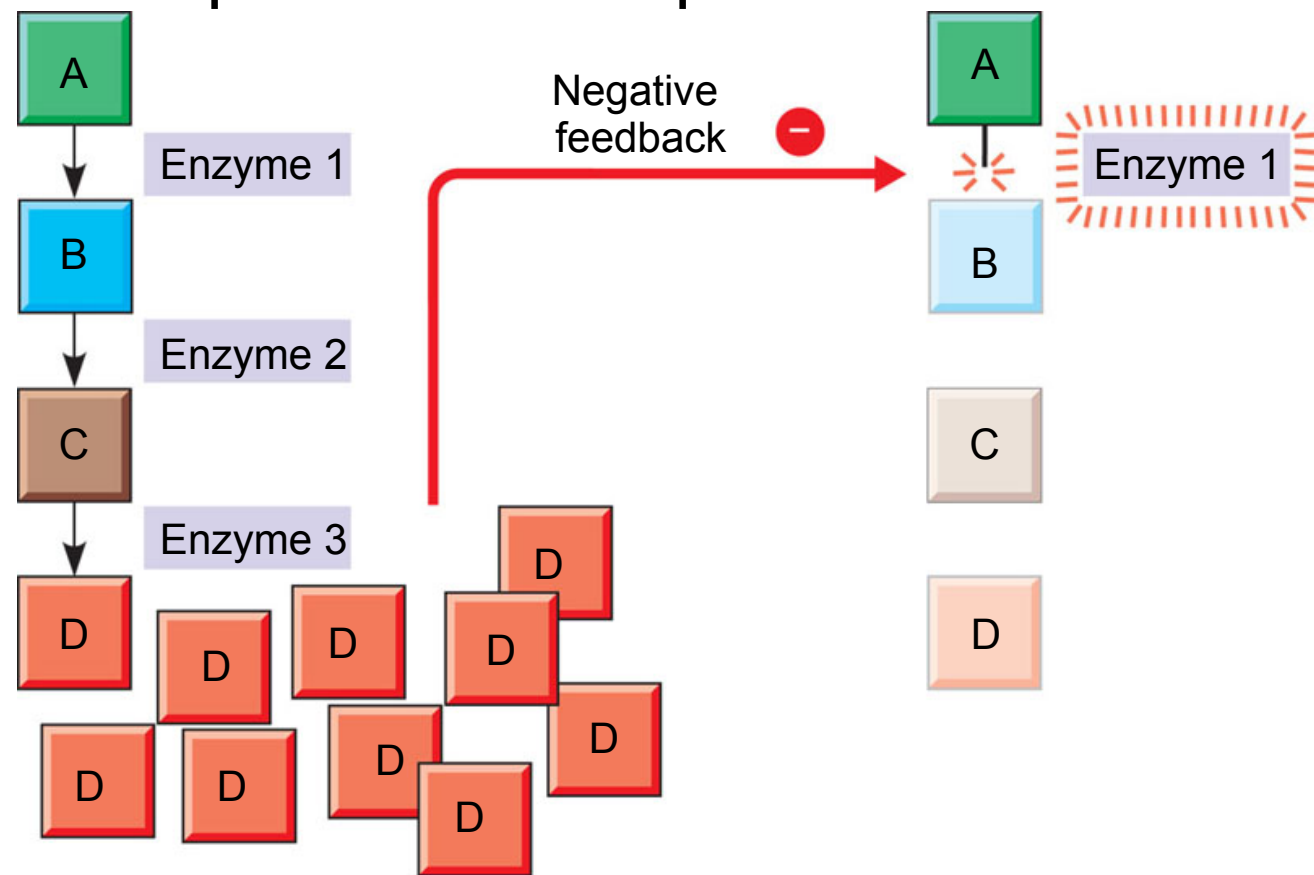
# Feedback Regulation in Biological Systems

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- A kind of supply-and-demand economy
  - Applies to some of the dynamics of biological systems

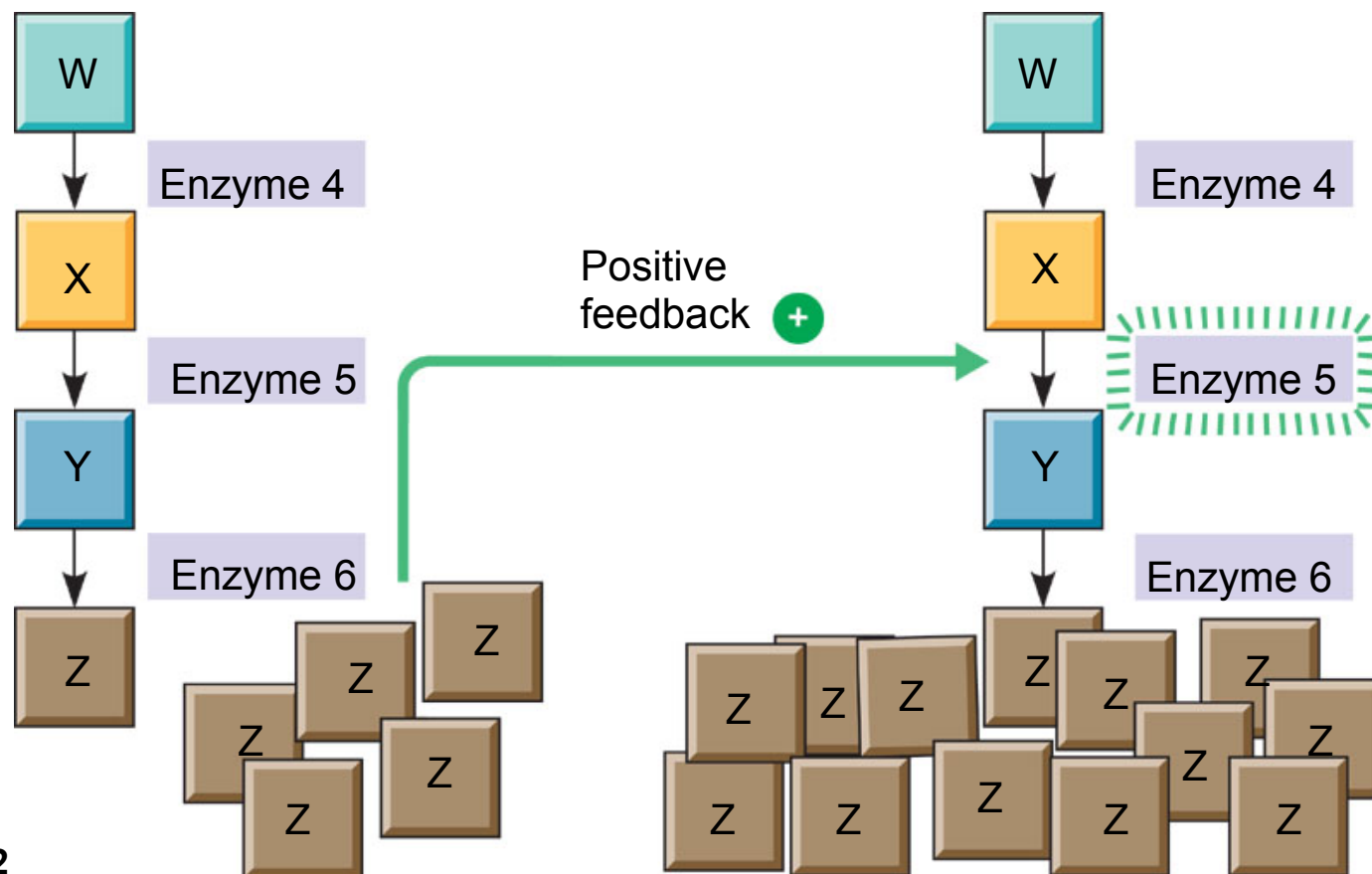
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- In feedback regulation
    - The output, or product, of a process regulates that very process

- In negative feedback
  - An accumulation of an end product slows the process that produces that product



**Figure 1.11**

- In positive feedback
  - The end product speeds up production



**Figure 1.12**



- 
- Concept 1.3: Biologists explore life across its great diversity of species
  - Diversity is a hallmark of life



**Figure 1.13**



# Grouping Species: The Basic Idea

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- Taxonomy
  - Is the branch of biology that names and classifies species according to a system of broader and broader groups

- Classifying life

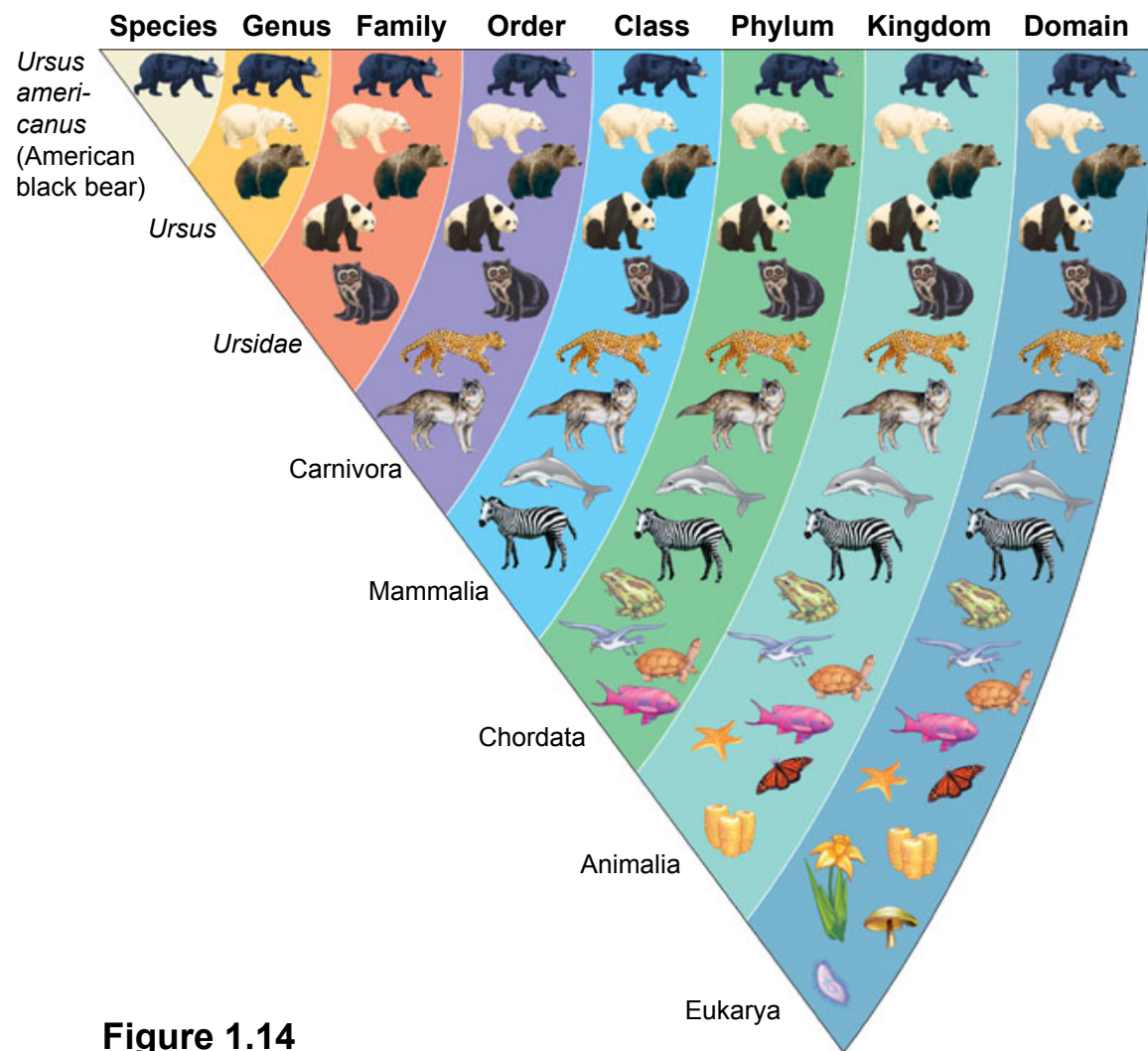


Figure 1.14

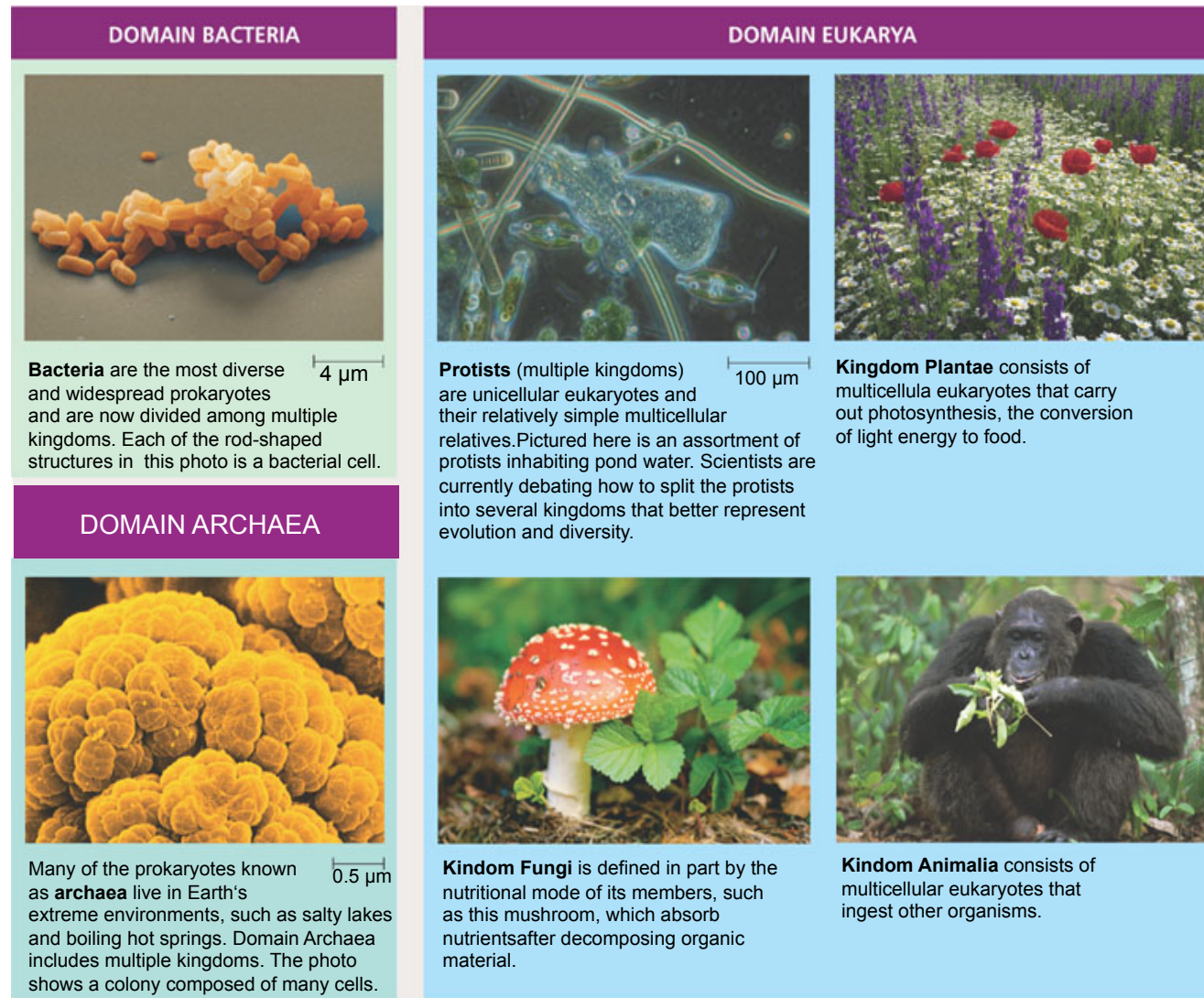
# The Three Domains of Life

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- At the highest level, life is classified into three domains
  - Bacteria
  - Archaea
  - Eukarya

- 
- Domain Bacteria and domain Archaea
    - Consist of prokaryotes
  - Domain Eukarya, the eukaryotes
    - Includes the various protist kingdoms and the kingdoms Plantae, Fungi, and Animalia

- Life's three domains

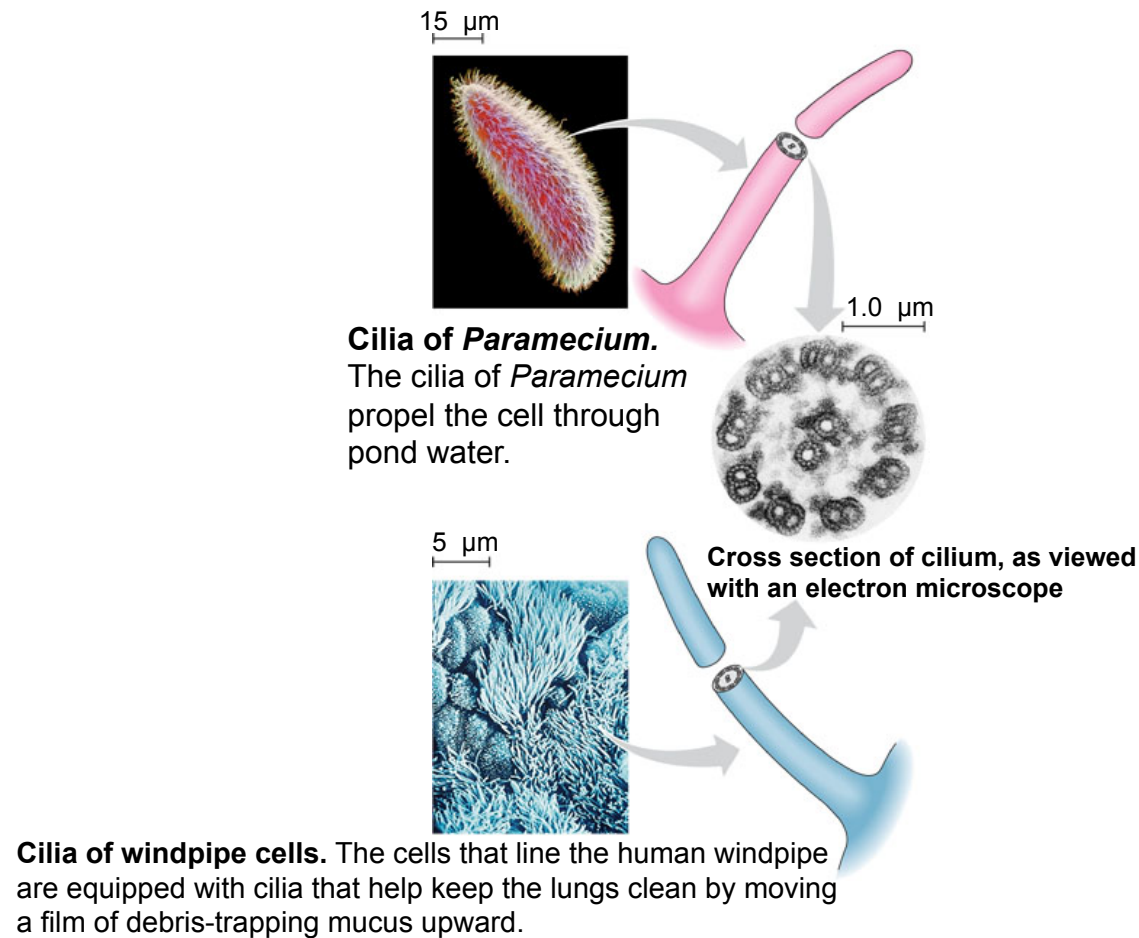


**Figure 1.15**

# Unity in the Diversity of Life

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- As diverse as life is
  - There is also evidence of remarkable unity



**Figure 1.16**

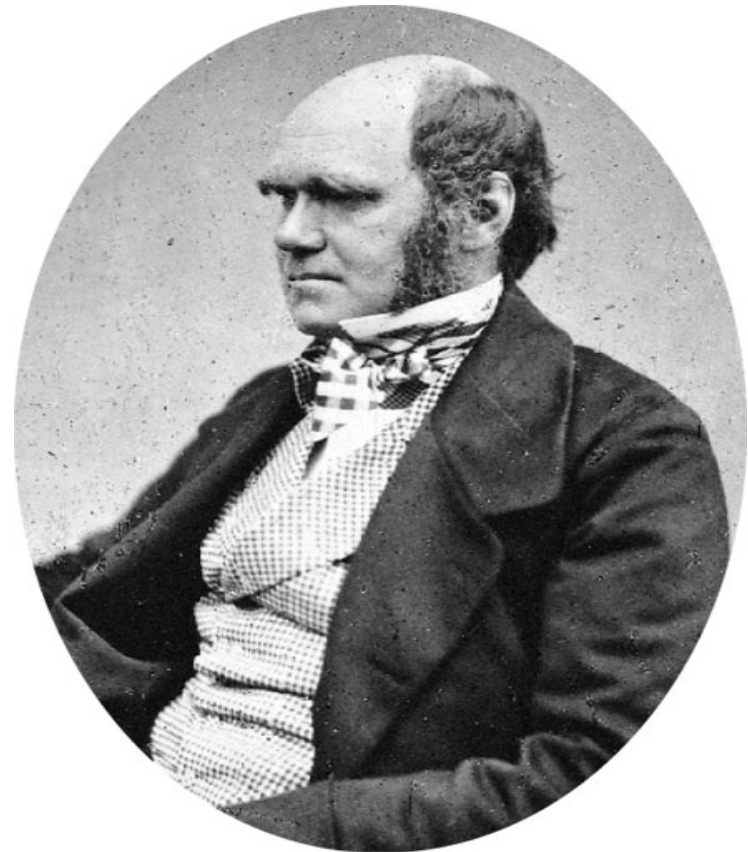


- 
- Concept 1.4: Evolution accounts for life's unity and diversity
  - The history of life
    - Is a saga of a changing Earth billions of years old



**Figure 1.17**

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- The evolutionary view of life
    - Came into sharp focus in 1859 when Charles Darwin published *On the Origin of Species by Natural Selection*

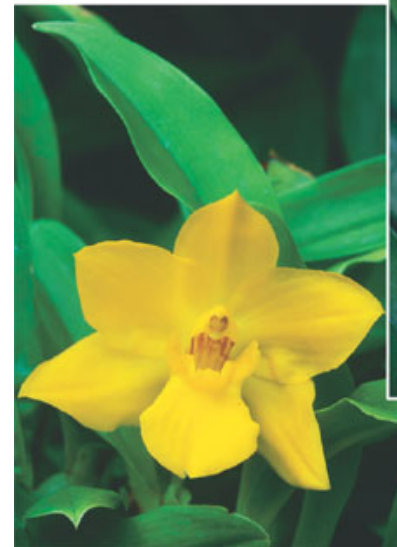


**Figure 1.18**



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- *The Origin of Species* articulated two main points

- Descent with modification
- Natural selection

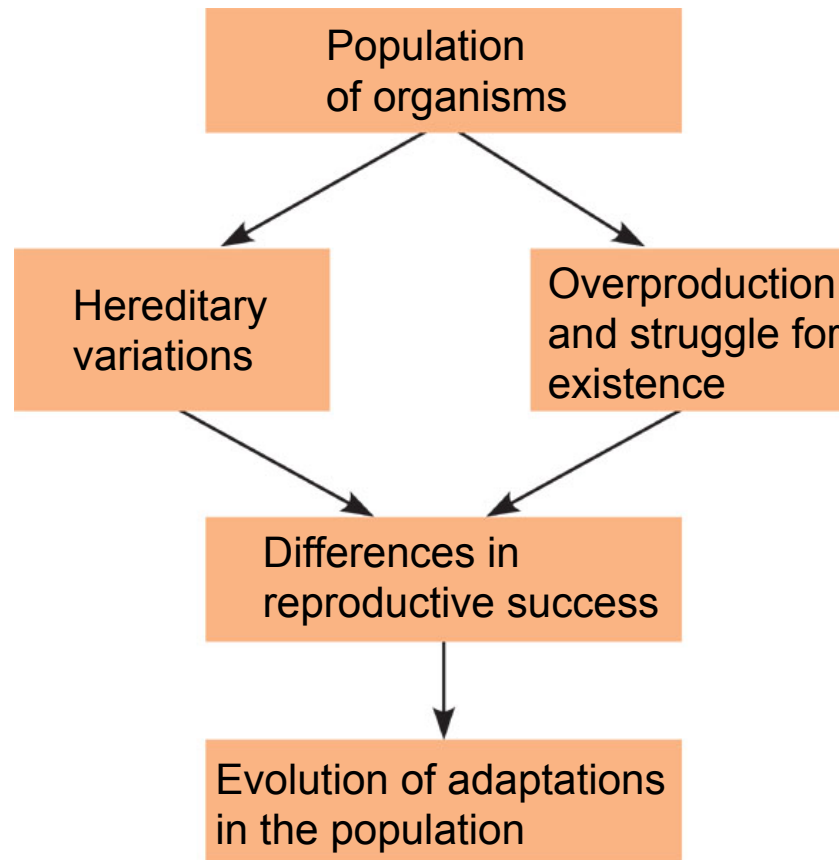


**Figure 1.19**

# Natural Selection

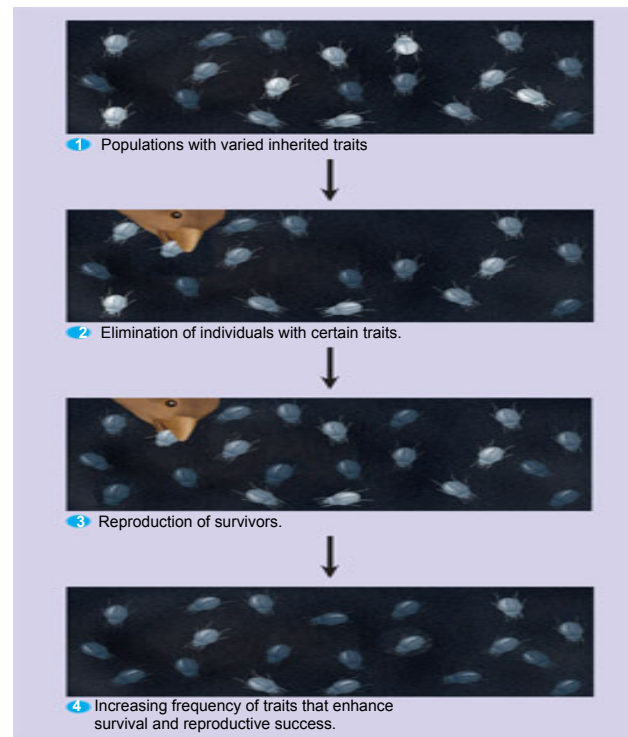
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- Darwin proposed natural selection
  - As the mechanism for evolutionary adaptation of populations to their environments



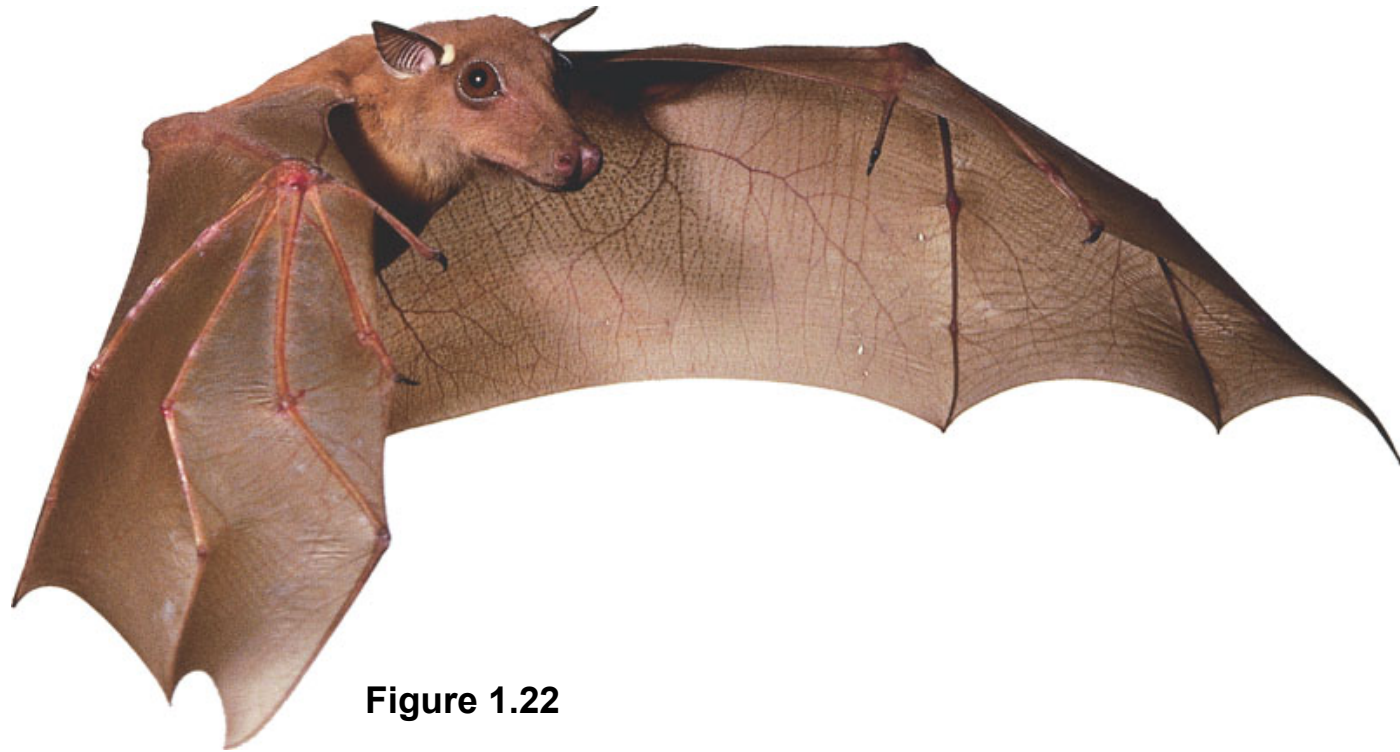
**Figure 1.20**

- Natural selection is the evolutionary process that occurs
  - When a population's heritable variations are exposed to environmental factors that favor the reproductive success of some individuals over others



**Figure 1.21**

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- The products of natural selection
    - Are often exquisite adaptations of organisms to the special circumstances of their way of life and their environment



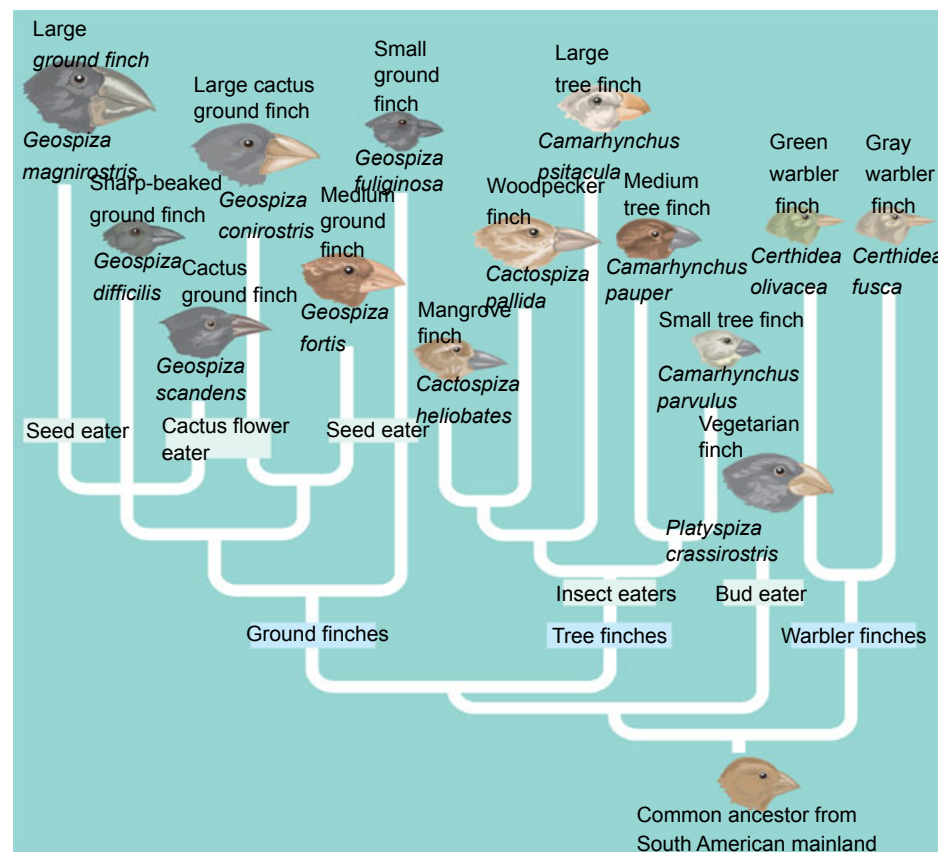
**Figure 1.22**

# The Tree of Life

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- Many related organisms
  - Have very similar anatomical features, adapted for their specific ways of life
- Such examples of kinship
  - Connect life's “unity in diversity” to Darwin's concept of “descent with modification”

- Darwin proposed that natural selection
  - Could enable an ancestral species to “split” into two or more descendant species, resulting in a “tree of life”



**Figure 1.23**

- 
- Each species is on twig of a branching tree of life
    - Extending back in time through ancestral species more and more remote
  - All of life
    - Is connected through its long evolutionary history

- 
- Concept 1.5: Biologists use various forms of inquiry to explore life
  - At the heart of science is inquiry
    - A search for information and explanation, often focusing on specific questions
  - Biology blends two main processes of scientific inquiry
    - Discovery science
    - Hypothesis-based science



# Discovery Science

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- Discovery science
  - Describes natural structures and processes as accurately as possible through careful observation and analysis of data

# Types of Data

- Data
  - Are recorded observations
  - Can be quantitative or qualitative



**Figure 1.24**

## *Induction in Discovery Science*

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- In inductive reasoning
  - Scientists derive generalizations based on a large number of specific observations

# Hypothesis-Based Science

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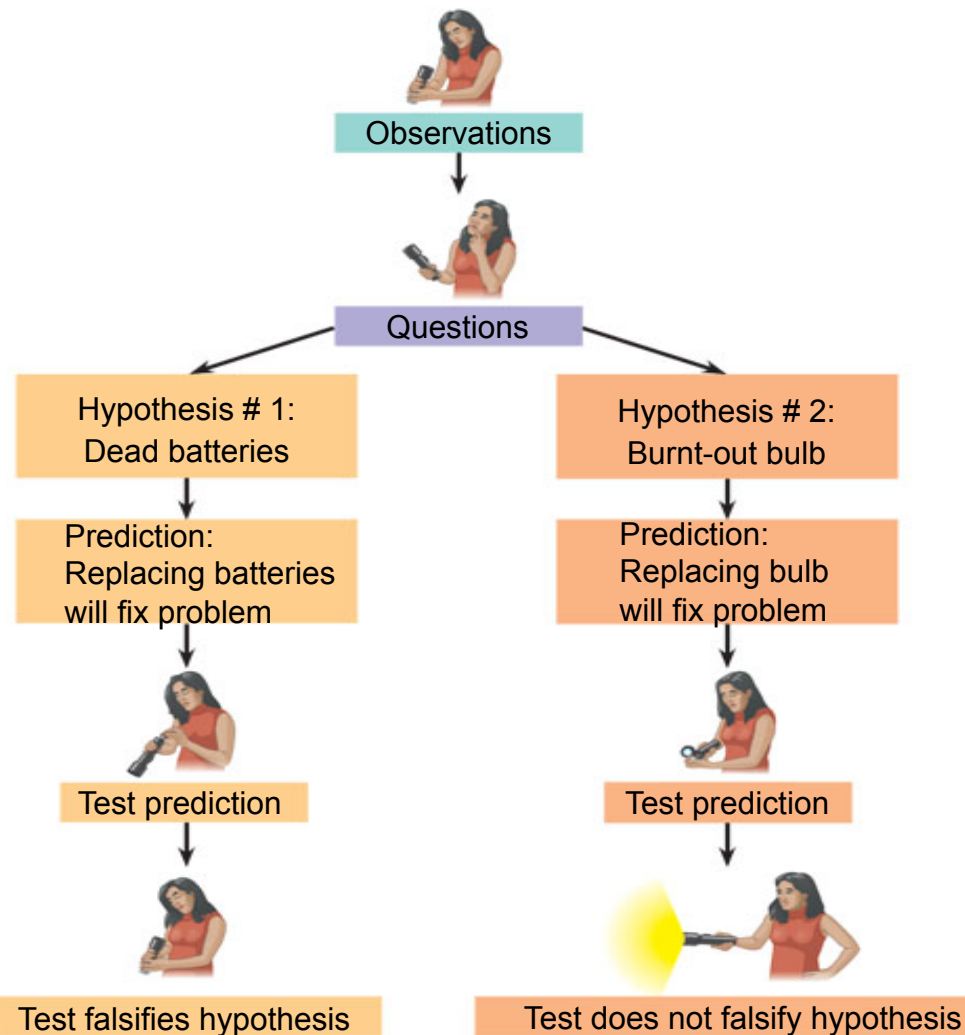
- In science, inquiry that asks specific questions
  - Usually involves the proposing and testing of hypothetical explanations, or hypotheses

## *The Role of Hypotheses in Inquiry*

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- In science, a hypothesis
  - Is a tentative answer to a well-framed question, an explanation on trial
  - Makes predictions that can be tested

- We all use hypotheses in solving everyday problems



**Figure 1.25**

## *Deduction: The “If...then” Logic of Hypothesis-Based Science*

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- In deductive reasoning
  - The logic flows from the general to the specific
- If a hypothesis is correct
  - Then we can expect a particular outcome

## *A Closer Look at Hypotheses in Scientific Inquiry*

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- A scientific hypothesis must have two important qualities
  - It must be testable
  - It must be falsifiable



## *The Myth of the Scientific Method*

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- The scientific method
  - Is an idealized process of inquiry
- Very few scientific inquiries
  - Adhere to the “textbook” scientific method

# A Case Study in Scientific Inquiry: Investigating Mimicry in Snake Populations

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- In mimicry
  - A harmless species resembles a harmful species

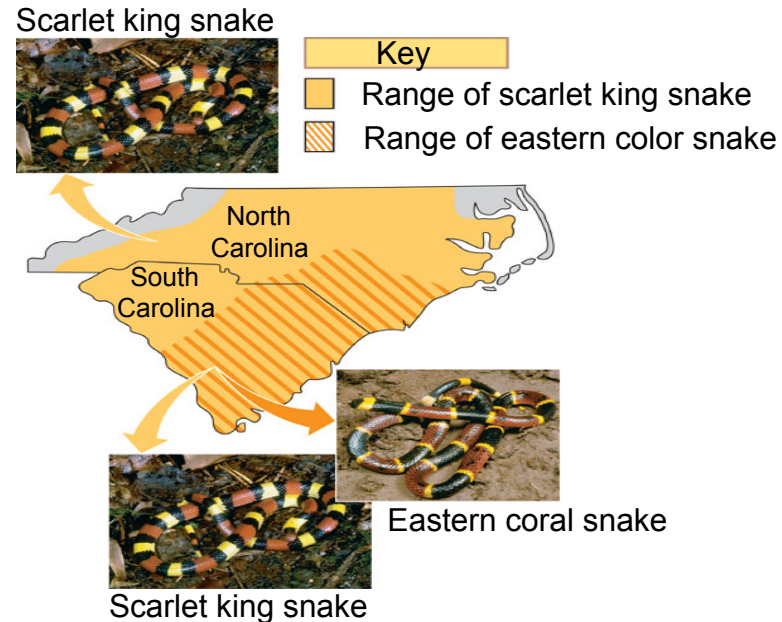
Flower fly  
(non-stinging)



Honeybee (stinging)

**Figure 1.26**

- In this case study
  - Mimicry in king snakes is examined
  - The hypothesis predicts that predators in non-coral snake areas will attack king snakes more frequently than will predators that live where coral snakes are present



**Figure 1.27**

## *Field Experiments with Artificial Snakes*

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- To test this mimicry hypothesis
  - Researchers made hundreds of artificial snakes, an experimental group resembling king snakes and a control group of plain brown snakes



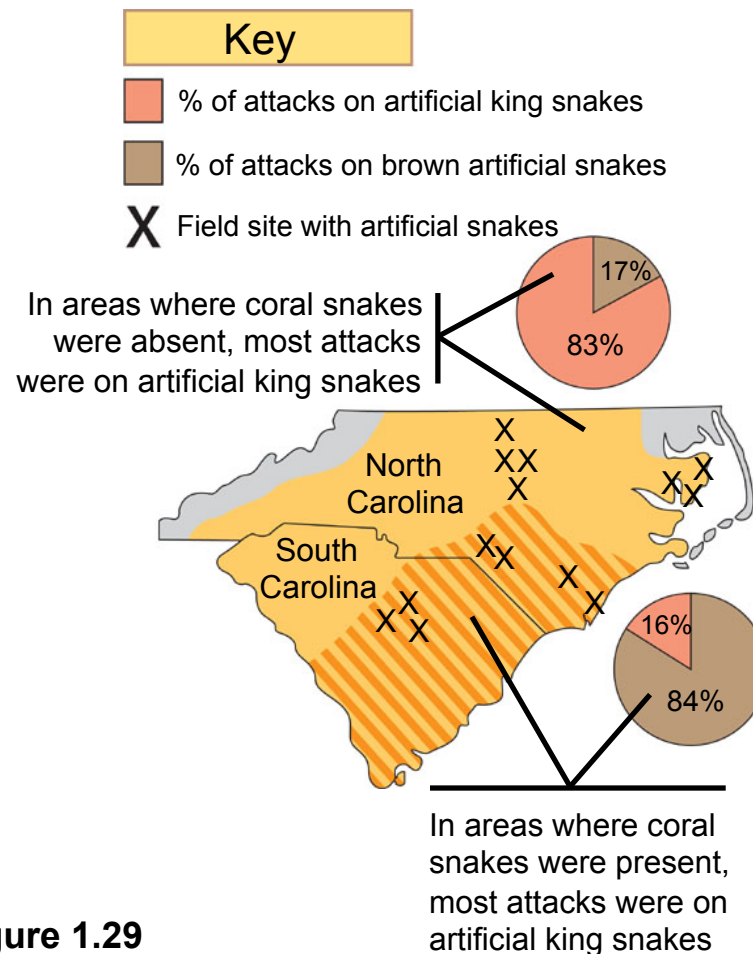
(a) Artificial king snake



(b) Brown artificial snake that has been attacked

**Figure 1.28**

- After a given period of time
  - The researchers collected data that fit a key prediction



**Figure 1.29**

## *Designing Controlled Experiments*

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- Experiments must be designed to test
  - The effect of one variable by testing control groups and experimental groups in a way that cancels the effects of unwanted variables

# Limitations of Science

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- Science cannot address supernatural phenomena
  - Because hypotheses must be testable and falsifiable and experimental results must be repeatable

# Theories in Science

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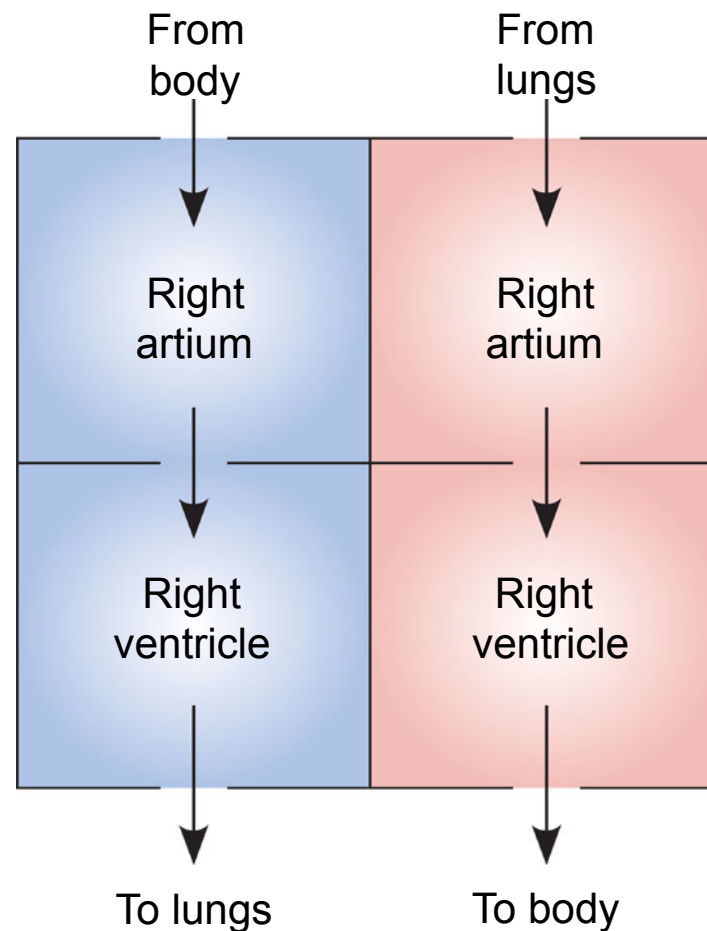
- A scientific theory
  - Is broad in scope
  - Generates new hypotheses
  - Is supported by a large body of evidence



# Model Building in Science

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- Models of ideas, structures, and processes
  - Help us understand scientific phenomena and make predictions



**Figure 1.30**

# The Culture of Science

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- Science is a social activity
  - Characterized by both cooperation and competition



**Figure 1.31**

# Science, Technology, and Society

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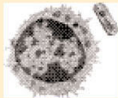

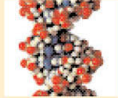
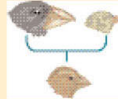
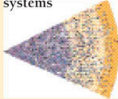



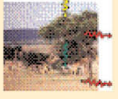


- Technology
  - Applies scientific knowledge for some specific purpose



**Figure 1.32**

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- Concept 1.6: A set of themes connects the concepts of biology
  - Underlying themes
    - Provide a framework for understanding biology

# - Eleven themes that unify biology

Theme	Description	Theme	Description
<b>The cell</b> 	Cells are every organism's basic units of structure and function. The two main types of cells are prokaryotic cells (in bacteria and archaea) and eukaryotic cells (in protists, plants, fungi, and animals).	<b>Unity and diversity</b> 	Biologists group the diversity of life into three domains: Bacteria, Archaea, and Eukarya. As diverse as life is, we can also find unity, such as a universal genetic code. The more closely related two species are, the more characteristics they share.
<b>Heritable information</b> 	The continuity of life depends on the inheritance of biological information in the form of DNA molecules. This genetic information is encoded in the nucleotide sequences of the DNA.	<b>Evolution</b> 	Evolution, biology's core theme, explains both the unity and diversity of life. The Darwinian theory of natural selection accounts for adaptation of populations to their environment through the differential reproductive success of varying individuals.
<b>Emergent properties of biological systems</b> 	The living world has a hierarchical organization, extending from molecules to the biosphere. With each step upward in level, system properties emerge as a result of interactions among components at the lower levels.	<b>Structure and function</b> 	Form and function are correlated at all levels of biological organization.
<b>Regulation</b> 	Feedback mechanisms regulate biological systems. In some cases, the regulation maintains a relatively steady state for internal factors such as body temperature.	<b>Scientific inquiry</b> 	The process of science includes observation-based discovery and the testing of explanations through hypothesis-based inquiry. Scientific credibility depends on the repeatability of observations and experiments.
<b>Interaction with the environment</b> 	Organisms are open systems that exchange materials and energy with their surroundings. An organism's environment includes other organisms as well as nonliving factors.	<b>Science, technology, and society</b> 	Many technologies are goal-oriented applications of science. The relationships of science and technology to society are now more crucial to understand than ever before.
<b>Energy and life</b> 	All organisms must perform work, which requires energy. Energy flows from sunlight to producers to consumers.		

**Table 1.1**